DSN Command System Mark III-75

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A description of the DSN Command System Mark III-75 configuration is presented. The functional operation of the system is discussed, as well as a brief description of the new implementation included in the Mark III-75 configuration.

I. Introduction

The DSN Command System, one of the six network systems, has almost completed the implementation of new capabilities and configurations to provide the required support to missions set for the 1975 to 1977 era. These changes will lead to completion of the Mark III-75 configuration. These configurations and capabilities will support the ongoing Pioneers 6 through 10, Pioneer Saturn, and Helios A missions. These configurations and capabilities will further support the Viking and Helios B missions. (At the time of submittal of this article, the first Viking Orbiter-Lander spacecraft had been launched and successfully supported by the DSN Command System. The second Viking launch is imminent.)

The DSN Command System Mark. III-75 configurations are shown in Fig.1. The significant changes that have occurred, or are occurring, to complete the Mark III-75 configurations are denoted in Fig. 1. These changes are occurring in two areas: (1) The Network Operations Control Center (NOCC), and (2) The 64-meter deep space stations (DSSs). The purpose of the NOCC is to provide capabilities to control and monitor the operation of the DSN Command System in an environment where widely separated deep space stations are simultaneously supporting different spacecraft. The Mark III-75 NOCC will provide the control and monitoring functions. The significant changes that are occurring at the 64-meter deep space stations are: (1) the implementation of an additional receiver–exciter (Block IV), and (2) the implementation of a high-power (100-kW) transmitter at the 64-meter deep space stations in Australia and Spain.

II. Data Flow and Functional Operation

The data flow and functional operation of the DSN Command System can best be described by defining three periods of operation: (1) pre-track, (2) during track, and (3) post-track. The following paragraphs describe the operation of the system during these periods. (Refer to Fig. 1 for data flow description.)

A. Pre-Track Operation

Prior to a spacecraft track, the DSS operations personnel perform the station countdown. This involves the selection of the equipment to be used, and the validation that a complete and correct data path has been established and that all support equipment is operating

within specifications. After the station countdown is complete (approximately 30 minutes prior to spacecraft acquisition), the control of the station's command functions is accomplished remotely via high-speed data messages from the NOCC.

The appropriate standards and limits, corresponding to the configuration, are established via high-speed data messages. Spacecraft-dependent parameters, such as symbol period, command subcarrier frequency, exciter frequency, and appropriate abort limits, are established via these messages. After the proper configuration and standards and limits have been established, test commands are transmitted through the system to ensure that the system can accept spacecraft commands via high-speed data messages, temporarily store the commands, and properly confirm transmission. After NOCC operations personnel have established that the system is operating properly, the system is ready to be turned over to the flight project for acceptance of actual spacecraft commands during the spacecraft track period.

B. During Track Operation

Commands generated at the Mission Operations Center are placed in high-speed data blocks and transmitted to the DSS command stack. The command stack provides storage of high-speed data blocks (stack modules) of command data. Each stack module consists of up to six command elements. Each command element contains up to 71 bits of command data and, at project option, can be either timed or nontimed.

Commands can also be entered and controlled locally at the DSS via a manual input/output device at the Command Processor. A manual buffer in the Command Processor, capable of holding up to six command elements of up to 71 bits each, can be loaded via the local input/output device or by high-speed data messages from the Mission Operations Center. The entire contents of the manual buffer or any one command element in the buffer can be transferred to the command stack.

The top command element in the first stack module is eligible for transmission to the spacecraft. Nontimed commands are transmitted immediately after eligibility. Timed commands are transmitted after becoming eligible at the time specified in the high-speed data block. At the time of transmission of the command element, the Command Processor establishes the proper mode (see Fig. 2 for description of the various modes) and configuration of the Command Modulator Assembly; then the command is transferred to the Command Modulator Assembly for immediate transmission via the Receiver–Exciter, Trans-

mitter, Microwave, and Antenna Subsystems. Related verification, confirmation, and abort criteria (if required) are established by the Command Processor.

During these command operations, events may occur in which high-speed data message transmission to the Mission Operations Center becomes necessary. The following events initiate message transmission to the Mission Operations Center:

(1) Confirmed command element.

(2) Aborted command element.

(3) DSS alarm or alarm clear.

(4) Response to a recall.

(5) High-speed data block rejection by the Command Processor.

(6) Acknowledged receipt of a high-speed data block.

A digital Original Data Record of DSN Command System activity is generated at the DSS. An analog record of the Command Modulator Assembly output is also generated at the DSS by the Pre-Post Detection Recording Subsystem.

During the spacecraft track, the NOCC receives all high-speed data messages being received by and generated by the DSS. DSN Command System verification, alarm diagnosis, and displays are accomplished by the NOCC.

C. Post-Track Operations

At the Mission Operations Center, during the commanding of the spacecraft, a data record is generated to provide a log of all commands transmitted to the spacecraft. The post-track operation period has been set aside to recover missing data, if, during the track, data failed to get logged on the data record. Data are extracted from the DSS Original Data Record and played back via high-speed data messages to the Mission Operations Center. The playback data are used to complete the data record at the Mission Operations Center.

III. NOCC Capabilities

The final configuration of the NOCC to support the Mark III-75 Command System is planned for completion in the last quarter of calendar year 1975. The NOCC has been implemented in three phases. The first two phases included minimum mandatory functions to accomplish Command System control and monitoring. These functions in many cases were awkward and inefficient to use. The third phase of implementation improves and adds to the

functions provided in the first two phases. The description below includes the functions to be provided in the third phase of implementation and completes the NOCC implementation for the Mark III-75 configuration.

A. High-Speed Data Message Generation

The NOCC will have the capability to generate the high-speed data messages required to be transmitted to the deep space stations. These messages include the following data:

(1) Configuration.

(2) Standards and limits.

(3) Test commands.

(4) Mode control.

(5) Recall request.

The first three types of data listed above contain spacecraft-unique parameters. Thus, numerous high-speed data messages are required. These messages are generally constructed and stored in advance of their use. However, the capability is provided to modify parameters within these messages for immediate transmission to a DSS.

B. High-Speed Data Message Transmission

Included in the capabilities at the NOCC are the functions of transmitting the high-speed messages to a DSS, verifying proper receipt at the DSS, and verifying proper processing by the DSS.

C. System Validation

During a spacecraft track, the NOCC monitors the operation of the system to ensure its proper functioning. Status messages from the DSS are received and processed, and displays are provided to DSN operations personnel. In the event of failure, these displays provide the necessary tools for failure isolation and system recovery.

IV. DSS Capabilities

As stated before, the major changes occurring to complete the Mark III-75 Command System at the deep space stations are: (1) the implementation of an additional receiver–exciter at the 64-meter stations, and (2) the implementation of 100-kW transmitters at the deep space stations in Spain and Australia. Completion of these implementations is planned within the next few months. The additional exciter will provide redundancy to a major element in the Command System. This will increase the ability of the DSN to provide faster command recovery times in support of the flight projects. The implementation of the high-power transmitters provides a significant increase in DSN uplink capabilities, as well as providing physical redundancy to another major element in the Command System.

V. Future Plans

After completion of the Mark III-75 configuration, the next major upgrade to the system is planned for support of the Mariner Jupiter/Saturn 1977 mission. Replacement of the obsolete Command Processors at the deep space stations is planned. This Mark III-77 configuration will include dedicated Command Processors at the deep space stations (current processors are shared between the command and telemetry functions at the DSS). These new processors will greatly increase processing speed and core available for the command functions at the DSS. This will allow the DSN to provide support to missions utilizing higher command bit rate transmissions. The relatively slow processing speed and core limitations existing in the current processor do not allow bit rate transmissions required by future spacecraft.
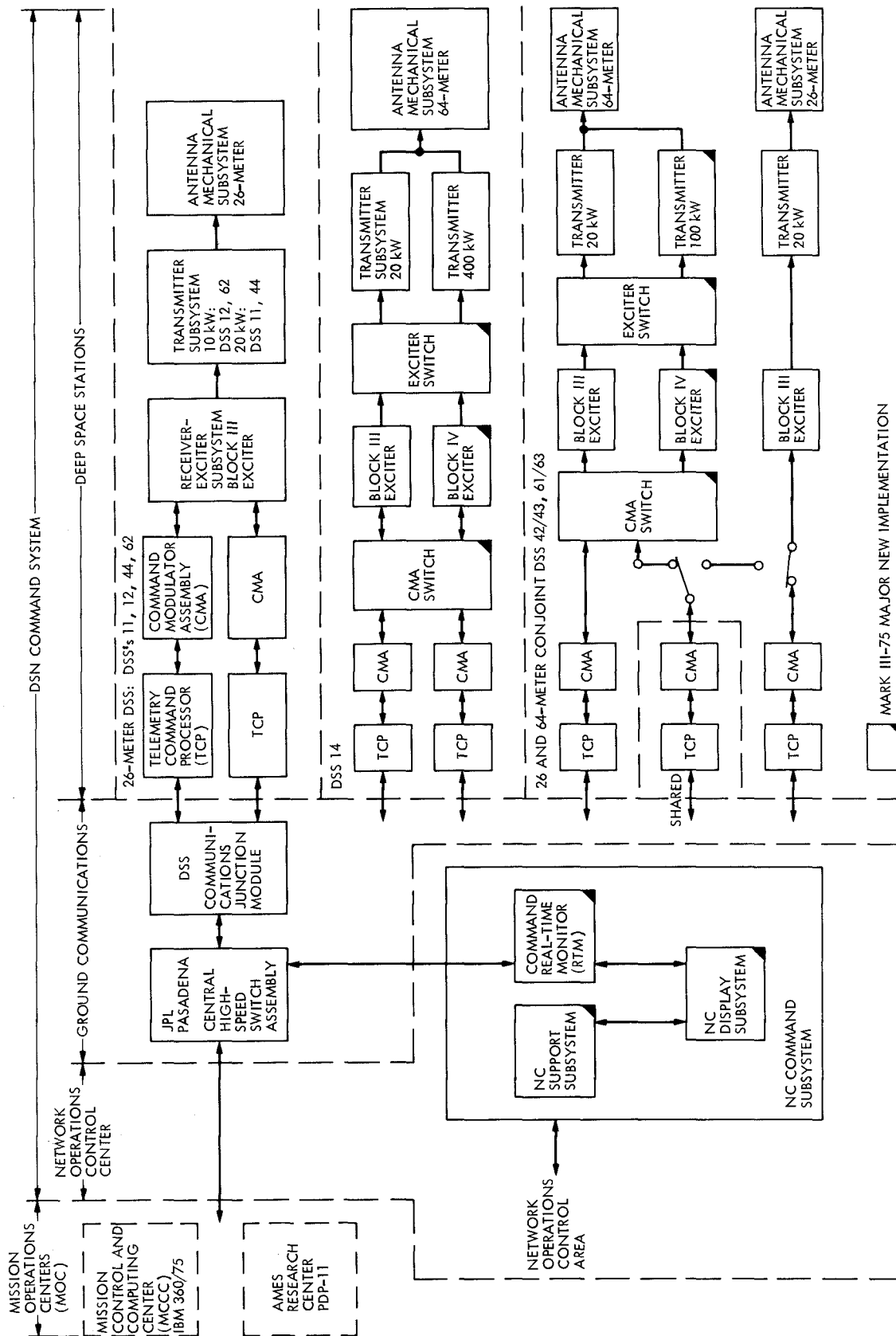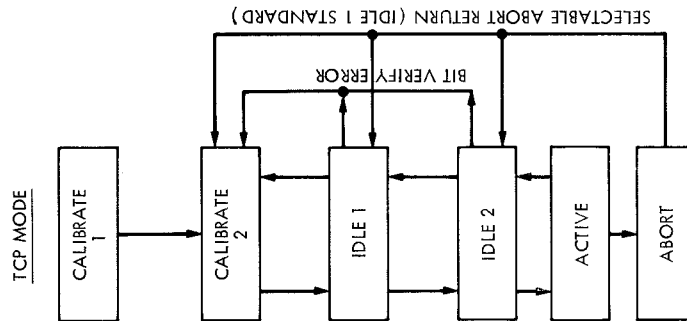
Fig. 1. DSN Command System Mark III-75 configuration

TCP MODE	PRIME PURPOSE	DATA ACCEPTED VIA HIGH SPEED	COMMENTS
CALIBRATE 1	ALLOWS DSS OPS PERSONNEL TO PERFORM INITIALIZATION TASKS	CONFIGURATION STANDARDS AND LIMITS, "MODE CONTROL," "RECALL"	UPON RECEIPT OF A STANDARDS AND LIMITS AND CONFIGURATION HSD BLOCK, THE CALIBRATE 2 MODE WILL BE ENTERED
CALIBRATE 2	STANDARD MODE FOR UPDATING STANDARDS AND LIMITS AND CONFIGURATION DATA VIA HIGH SPEED PRIOR TO SPACECRAFT ACQUISITION	CONFIGURATION STANDARDS AND LIMITS "MODE CONTROL," RECALL	MULTIMISSION STANDARD PROCEDURES SHOULD STATE THAT THIS MODE IS TO BE ENTERED FOR CHANGING SUBCARRIER FREQUENCY, BIT RATE
IDLE 1	SAFE MODE – CANNOT COMMAND. PROVISION FOR IDLE/ACQUISITION SEQUENCE. ALLOWS CONFIGURATION AND STANDARDS AND LIMITS TO BE CHANGED	CONFIGURATION STANDARDS AND LIMITS "MODE CONTROL," RECALL	ALL STANDARDS AND LIMITS AND CONFIGURATION DATA PARAMETERS WILL TAKE IMMEDIATE EFFECT IN THIS MODE
IDLE 2	ALLOWS ENTRY INTO ACTIVE MODE. PROVIDES IDLE/ACQUISITION SEQUENCE DURING COMMAND PERIODS	RECALL AND MODE CONTROL DATA ONLY	MODE CONTROL DATA CONTAINED IN THE COMMAND ELEMENT BLOCK FOR THE MARK III-75 COMMAND SYSTEM
ACTIVE	COMMAND TRANSMISSION	RECALL AND MODE CONTROL DATA ONLY	
ABORT	PROVIDES ABORT INSTRUCTION TO CMA	RECALL AND MODE CONTROL DATA ONLY	

SELECTABLE ABORT RETURN (IDLE 1 STANDARD)

BIT VERIFY ERROR

NOTES:
1. COMMAND DATA MESSAGES WILL BE ACCEPTED IN ALL MODES
2. ALARM MESSAGES/ALARM DATA WILL BE TRANSMITTED TO THE MOC IN ALL MODES EXCEPT ABORT

Fig. 2. System mode description